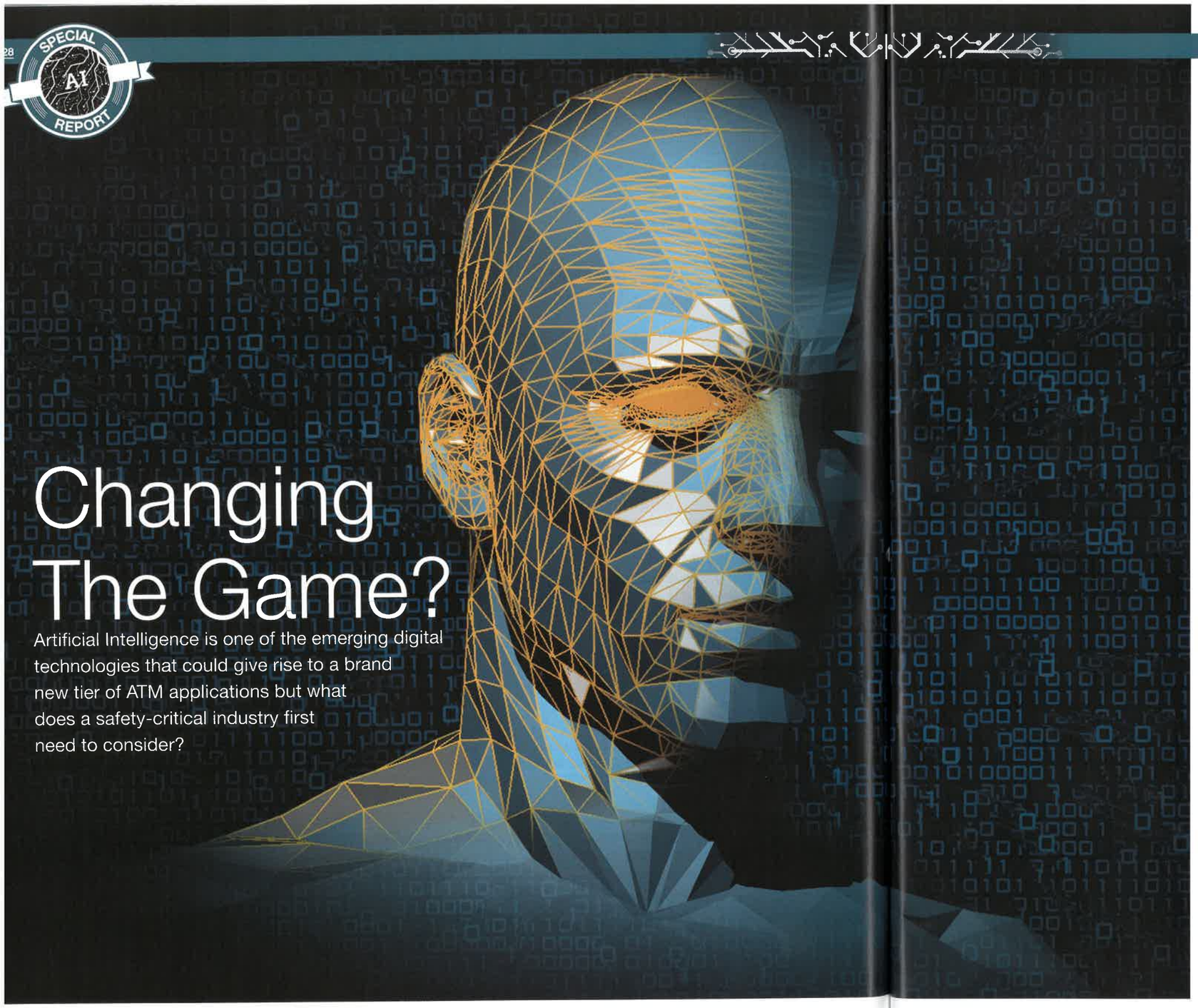

Changing The Game?

Artificial Intelligence is one of the emerging digital technologies that could give rise to a brand new tier of ATM applications but what does a safety-critical industry first need to consider?

Artificial Intelligence (AI) tools are increasingly being viewed with significant interest by the ATM industry, intent as it is on handling flights and managing traffic at airports with ever more efficiency and safety, *writes Aimée Turner*.

Forget about the consumer industry-hyped Disney vision of AI or the Hawking-esque doom laden prognostications foretelling of the imminent destruction of the human race, AI could soon be enabling new ATM functionalities such as predictive runway incursion, collision detection, operational performance analytics and vision and speech processing. All of which have the potential to future-proof the industry's performance against a background of potentially runaway growth.

Operationally, AI is merely a means to augment the automation that already exists in today's ATM systems to enable the human controller to more efficiently ensure safe operations, according to Todd Donovan, Thales' vice president, digital aviation, ATM.

The main difference today is that historical data can be mined by AI's profound learning capability and thus provide more sophisticated, intelligent and potentially adaptive support tools.

Claire Blejean, a consultant at UK-based consultancy Helios, has a particular interest in data science, including big data, machine learning and AI techniques. She says the principle behind machine-learning algorithms - the building blocks of AI - is that they can modify themselves and improve, unlike traditional programs where the code remains fixed. The more data fed into an AI program, the better it performs. Of course, the quality of the program can only be as good as the quality of the data used to train it but this remarkable adaptability is what generates the main benefits of using AI: prediction and optimisation.

According to Blejean, the actual methodology behind machine-learning algorithms is far from recent with the fundamentals drafted back in the 1950s. It is rather the incredible development in computer technology, both in terms of storage and processing power, that has finally enabled the application of these algorithms.

The significant volume of operational data from multiple sources such as weather reports, historical trends, real time pilot updates, GPS, radar and ADS-B data, to mention just a few, is starting to enable AI to perform ATM tasks which have until now been beyond the realm of humans: complex decision making. "More interestingly, it may also be able to recognise patterns which have eluded us so far, in order to do accurate forecasting and maximise the use of our airspace," she says.

It is by using automation that the cognitive burden on the human can be managed by prioritising workload. This allows for the scaling-up of operations and provides a system that is not prone to human limitation such as tiredness, attention span etc.

But this is not the whole story. Adding the significant number of aviation stakeholders to the mix - each having the authority to impact the functioning of the system - means that any ability to capture patterns through crunching huge datasets will inevitably need to be supervised by a rules-based expert system. It is generally agreed that the human will remain responsible for marrying AI's extraordinary firepower with the needs of such a highly complex and dynamic environment.

It is through linking man and machine that AI can leverage its go-further potential in ATM in a way that was not previously possible, with the human supervising AI agents to provide efficient, robust and reliable outcomes in a sustained manner.

One of the greatest challenges to AI's progress will no doubt come down to cultural acceptance which is expected to be driven through increased access to consumer products in daily life. Still, as one industry expert puts it succinctly: "Players in the consumer world have not solved [errors in machine-learning] because they do not have to. An error is not too serious when nothing more than a shopping recommendation is at stake."

Trust

Dr Claire Le Cras, senior research analyst with UK provider NATS agrees: "It's a lot to do with building trust, which can only come from the accuracy of the output and through the extra value we add by expert human analysis of the data. While machines offer the incredible benefit of being able to digest and spot things in vast volumes of data in a way that our brains could never do, the results only really come to life with the addition of a human touch."

She is part of a team that helped NATS introduce machine learning in 2017 to help predict the likelihood of potential safety events – such as aircraft level busts, or airspace infringements – in the London Terminal Control operation. "By using real-life data from 2015 to the present day, we use computer algorithms to find possible links between safety events and variables such as high traffic volume, airport runway direction, weather conditions and more."

NATS now uses this data to present a weekly forecast to its Swanwick Centre, suggesting corrective action to prevent potential issues.

Several AI initiatives are also underway in ATM, and aviation as a whole. Eurocontrol and the United States' FAA recently partnered in the organisation of a workshop at Eurocontrol's Brétigny research centre to explore the current state of machine learning and AI in the industry.

Helios' Blejean reports that many research projects are performing post-facto analysis using the commercially available PLUS software from the Safety Data Analysis Service which offers natural language processing capability on flight reports while Rowan University is working on image processing of cheap cameras capturing helicopter dashboard gauge values in order to replace expensive black boxes.

These projects are replacing current tools or offering new insights into correlated factors and are likely to be the first step in introducing AI to the ATM world, as they can perform a non-safety critical role. However some more ambitious projects are aiming to develop tools which can support controllers in real time. For example, the Mallorca project from the IDIAP research institute in Switzerland is working on the automatic recognition of ATC command from voice and radar data; while Eurocontrol is spearheading its own machine learning project to provide additional runway throughput capacity. Its system can actually predict which runway exit gate will be used with 80 per cent accuracy. Other projects are trying to automatise airspace design to optimise capacity such as ENAC's research into optimal sector configuration which attempts to anticipate controller overload.

"At the moment, many of these projects are still in their research and development stage and none of these tools are expected to replace humans," says Blejean.

Even so, she says that as they develop and humans come to rely on them more, it will be important to re-examine questions of responsibility and accountability.

So what will be the basic AI performance requirements and how does the industry go about evaluating them?

The industry prides itself on its impressive safety record, says Blejean, so the standard that controllers are held to today is the bare minimum of what AI programs should offer.

"Although an AI algorithm evolves and improves the more data is entered into it, it does so according to some built-in incentives. In ATM, the number one incentive should be the protection of human life, this should take precedent over all other concerns. Once it is satisfied other incentives such as maximising capacity, reducing delay, minimising fuel consumption, and others, may come into play," she says.

Thales' Donovan introduces a further consideration. He says that while AI can be applied in many places, certification of AI capabilities remains a real challenge. "Since AI is adaptive, the same AI system will potentially provide a different output to the same input if it has been trained with different historical data. Our industry doesn't know how to certify this sort of a system and there is considerable work ongoing in the area of 'provable AI' which is required to bring AI into the safety critical operational domains."

Forecast Output

NATS' Le Cras agrees: "What you get out depends on the quality of what you put in, so choosing the right things to measure in the first place, picking the right algorithms and then carefully analysing the results is vital. That is why we consciously selected a machine learning approach in which the reasoning for the specific forecast output is included, also helping to alleviate the 'black box' concerns."

The fear here is that some widely-used models such as deep learning, are so-called 'black box', in so much that while the human can clearly see both the input and output, it is hard to observe what is going inside the model - a serious concern in terms of reliability and trust.

This is also a potential trade-off between accuracy and scalability, a problem currently encountered by developers. "As computers continue to increase their storage and computing capability, this issue may become less relevant," says Blejean. "It is also important to make sure we understand that using AI programs does not shield us from responsibility."

So how does the industry define the responsibility of AI? Blejean believes traditional methods of certifying a computer program are becoming insufficient as machine learning algorithms evolve so they need be audited at regular intervals, very much like the human controller.

Responsibility

If an AI program doesn't perform adequately, without having been tampered with, then there can be two main reasons: either it was not trained properly, or the built-in incentives which AI follows to improve itself are faulty. In the event of an incident, the software would need to be tested to ensure it has been implemented according to requirements. If this is the case, the following questions need to be asked: what are the fundamental values\principles\built-in incentives? has it had sufficient training? was the training\ data appropriate? was its performance monitored, and what are the KPIs used for evaluating that performance? Were changes implemented in a controlled way?

"Depending on the answers to these questions, the responsibility may lie with the users, the developers, or external factors," she says.

"building trust can only come from the accuracy of the output and the extra value of expert human analysis"

Todd Donovan at Thales adds: "ATM is a human-centred activity and we don't see that changing in the foreseeable future so the technology must be designed to help improve human performance. Safety is paramount in aviation therefore, we don't expect extensive use of AI in ATM systems until we overcome the provable AI challenge. At that point, AI will be no different than any other technology which is implicated in an accident."

And what of the human's role within an AI-assisted working environment?

Giusy Sciacca is a working tower controller at Milan Linate and a member of an International Federation of Air Traffic Controllers' Associations (IFATCA) group that is consulted by the European Commission on the impact of emerging technologies.

"In IFATCA's view of the future, AI in ATM will always include the human and the irreplaceable contribution of the operator. We firmly believe in the development of a joint human-machine cognitive system, a co-operative paradigm where technology and the human are interdependent. This is how we see the transformation of ATM could be over the coming 10 to 20 years," she says. "Considering the employment of AI in ATM we would first see controller rostering and ATFM as first directions, being mainly based on digital data at a network level," she adds.

She points out that IFATCA makes no especial distinction between AI and automation in general. Federation policy here stipulates that automated systems must be fail-safe, provide accurate and incorruptible data and have an inbuilt integrity factor to review and crosscheck the information being received.

IFATCA further prescribes that total workload should not be increased without proof that the combined automated/human systems can operate safely in both normal and abnormal situations.

Automated tools or systems that support the control function must also enable the controller to retain complete control to be able to make timely interventions when situations occur that are either outside the normal compass of system design or when abnormal situations occur which require noncompliance or a variation from normal procedures.

The Civil Air Navigation Service Organisation (CANSO) has spotted the need to address the impact on the human as automation reaches new levels within the industry.

At the CANSO Global ATM Safety Conference held in November in Banff, Canada, its deputy director general Simon Hocquard said the industry needed to continue to embrace new technologies and potentially new ways of managing airspace.

He cited transformative technologies such as advanced automation, AI and space-based surveillance as better tools with which to monitor and measure safety and ensure that 'tomorrow will be even safer'.

"The role of the human also becomes even more important in this new digital age, as change requires people to adapt to new technologies and ways of working. As we adopt new technologies and an increasingly automated system, we are building a clear vision for the human and ensuring a safe and seamless transition through effective human performance management."

CANSO is, with that in mind, planning to develop a standard of excellence in human performance management to help air navigation service providers manage these critical changes and establish the human's essential role in this brave new world. ATM